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Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	Oceans	Limestone
Longest Residence Time	Oceans glaciers	Limestone
Which is more important for driving processes, gravitational or chemical energy?	Gravitational Thermal	Chemical Thermal
How are evaporation and degassing SIMILAR?	For both the water cycle and carbon cycle, water and gas are being moved INTO the atmosphere.	
How are evaporation and degassing DIFFERENT?	There is thermal energy involved in the evaporation process but during degassing, the gas stays as a gas as it enters the atmosphere.	

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Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

- a. How would this uplift impact the residence time of CO₂ in the atmosphere?

The residence time of CO₂ in the atmosphere would increase due to the increased size of the reservoir as CO₂ enters atmosphere.

- b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

The increase of CO₂ in the atmosphere has increased the rate of weathering of rocks.

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

The industrial revolution increased the residence time of CO₂ in the atmosphere. because it increased the size of the reservoir of CO₂ in the atmosphere.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

Ocean Acidification increases the residence time of CO₂ in the ocean because of the increased amounts of CO₂ in the atmosphere.

Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

Carbon cycle

GROUP #:

Student IDs of Members Present:

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Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	Ocean, Glacier, streams, clouds, Groundwater (soil)	Atmosphere (CO_2 , methane) lithosphere Oceans (CaCO_3 , CO_2 , HCO_3^-) (limestone CaCO_3) Biosphere (organic carbon) coal, oil gas
Processes	Evaporation Discharge precipitation Condensation Sublimation recharge	Degassing, Burial, Cement Ocean acidification production Photosynthesis/Respiration
Residence Times	lower residence time: lower cont water in reservoir, inflow/outflow up	more or less the same

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs:

A storage place for water
ex. streams, clouds, underground

2. Evaporation:

The process of liquid leaving the earth into
the atmosphere through thermal energy.
Liquid turning to gas

3. Degassing:

when gas (CO_2) moves from ocean to Atmosphere

4. Chemical Energy (when is energy used and when is energy released?)

Energy released when bonds are being formed;
energy used when bonds are being broken.

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Cycles

Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	Oceans	Biosphere
Longest Residence Time	Oceans	Lithosphere
Which is more important for driving processes, gravitational or chemical energy?	Gravitational	Chemical - has to change chemical makeup to go through dif. reservoirs
How are evaporation and degassing SIMILAR?	Both evaporation & degassing both involves put taking substances from the earth/ocean and putting them into the atmosphere.	
How are evaporation and degassing DIFFERENT?	In evaporation substances go from liquid to gas. And in degassing is a gas the entire process	

2

Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

- a. How would this uplift impact the residence time of CO₂ in the atmosphere?

The residence time would go down because inflow is higher

- b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

More CO₂ means global warming which has increased precipitation which would increase the weathering rate of rocks.

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

Humans burning fossil fuels has increased the amount of CO₂ in the atmosphere which cause the residence time of CO₂ in the atmosphere.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

Deforestation means less trees to take in the CO₂ causing a decrease in residence time

2

Part 3: Homework

If you complete the group work, you may work on the homework on your own. This means your answers should be generally unique from other students' answers. **Submit your homework using ANGEL.**

1. Describe what it means for a reservoir to change size.
2. Describe a situation where the residence time for a reservoir in the carbon cycle is **increased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
3. Describe a situation where the residence time for a reservoir in the carbon cycle is **decreased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
4. How does an atom of carbon move from coal into the atmosphere? Explain what would happen to Earth's temperature if the processes that move carbon into the atmosphere slowed down.
5. Recall our earlier work with ocean acidification. How does an atom of carbon move from CO₂ in water into rock? How would an increase in the processes that move carbon into rock impact Earth's temperature?
6. Just for fun: How does an atom of carbon move from HCO₃ in water into carbon in your skin?

2

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	ocean, glaciers, lakes, clouds, groundwater	atmos (CO ₂ , CH ₄) oceans (CaCO ₃ , CO ₂ , HCO ₃ , ...) biomass (organic)
Processes	evaporation, precip. condensation	degassing, burial, ocean acidification, photosyn/respiration
Residence Times	longer: ↑ amount of H ₂ O in and out.	more or less the same

lithosphere (limestone - CaCO₃)

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs:

A place where carbon, water, etc. is stored

2. Evaporation:

the process of water from liquid to gas.

3. Degassing:

CO₂ moving from/within a reservoir

4. Chemical Energy (when is energy used and when is energy released?)

used - break bonds

released - forming bonds

Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

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Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

a. How would this uplift impact the residence time of CO₂ in the atmosphere?

R.T. would be higher

- b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

Weathering occurs at the same rate

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

When a forest gets slashed & burned, it releases all the CO₂ into the atmosphere & ↑ R.T.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

There would be more CO₂ in the atmosphere (above situation)
so ↑ R.T.

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Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	Ocean	limestone biomass - trees
Longest Residence Time	Ocean (biggest res. = longest RT)	limestone biomass
Which is more important for driving processes, gravitational or chemical energy?	gravitational (rain, discharge infiltration)	chemical
How are evaporation and degassing SIMILAR?	both are chemical compounds that move $H_2O \rightarrow H_2O$ $CO_2 \rightarrow CO_2$	
How are evaporation and degassing DIFFERENT?	evaporation changes H_2O from liquid to gas but degassing keeps CO_2 the same	

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Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs		
Processes		
Residence Times		

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs: Anything that stores water or carbon.
2. Evaporation: The movement of water molecules from the hydrosphere to the atmosphere
3. Degassing: The movement of gaseous carbon from the hydrosphere to the atmosphere
4. Chemical Energy (when is energy used and when is energy released?)
Chemical energy used when forming and released when breaking forming bonds

Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	Oceans because the earth is 70% water	Atmosphere because it holds numerous carbon compounds.
Longest Residence Time	Oceans 3,200 yrs	Limestone, because it is a solid compound.
Which is more important for driving processes, gravitational or chemical energy?	Gravitational energy	Chemical energy
How are evaporation and degassing SIMILAR?	They are similar because they both involves the movement of molecules	
How are evaporation and degassing DIFFERENT?	In degassing it stays a gas, but in evaporation it moves from liquid -> gas	

4

Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

a. How would this uplift impact the residence time of CO₂ in the atmosphere?

It would decrease residence time because there would be carbon in the oceans.

b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

It would increase weathering because of the increase amounts of CO₂ in the atmosphere.

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

If a mountain is formed then the lithosphere reservoir is changed thus the residence time is changed by ~~decr~~ increasing.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

Part 3: Homework

If you complete the group work, you may work on the homework on your own. This means your answers should be generally unique from other students' answers. **Submit your homework using ANGEL.**

1. Describe what it means for a reservoir to change size.
2. Describe a situation where the residence time for a reservoir in the carbon cycle is **increased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
3. Describe a situation where the residence time for a reservoir in the carbon cycle is **decreased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
4. How does an atom of carbon move from coal into the atmosphere? Explain what would happen to Earth's temperature if the processes that move carbon into the atmosphere slowed down.
5. Recall our earlier work with ocean acidification. How does an atom of carbon move from CO₂ in water into rock? How would an increase in the processes that move carbon into rock impact Earth's temperature?
6. Just for fun: How does an atom of carbon move from HCO₃ in water into carbon in your skin?

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Cycles

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Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

GROUP #: 5
Student IDs of Members Present:
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Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	The oceans, glaciers, lakes, clouds, streams, ground water.	Atmosphere (CO_2 , CH_4) Lithosphere (limestone, fossil fuels) Oceans (CO_2 , HCO_3^- , CaCO_3) Biomass (Sugars, organic carbon)
Processes	Evaporation, condensation, Precipitation, discharge, sublimation, infiltration	Degassing, burial, ocean acidification, Photosynthesis, Respiration, weathering
Residence Times	Lower R.T. – lower amount of water in Reservoir. inflow at outflow ↑	more or less the same as the water cycle.

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

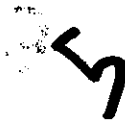
1. Reservoirs: where something is stored; with water, a reservoir could be a stream, or a lake, et al.
2. Evaporation: The process through which a liquid becomes a gas.
3. Degassing: this happens when a gas (CO_2) moves from a liquid to the atmosphere.
4. Chemical Energy (when is energy used and when is energy released?)
Energy stored in chemical form; it is used and released at the same time (eg. Fire).



Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	oceans glaciers	Limestone
Longest Residence Time	glaciers	Limestone Fossil Fuels
Which is more important for driving processes, gravitational or chemical energy?	gravitational energy (both are important)	chemical energy
How are evaporation and degassing SIMILAR?	they are both the movement of from liquid to a gas.	
How are evaporation and degassing DIFFERENT?	They are different in that with evaporation is a phase change, whereas degassing just movement of a gas.	



Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

- a. How would this uplift impact the residence time of CO₂ in the atmosphere?

Residence time would decrease.

- b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

This has caused the weathering rate of these materials to increase (eg. acid rain, at home).

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

Because humans have been burning fossil fuels, this has changed the residence time, making it shorter.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

Weathering has increased, so the residence time in the limestone reservoir of carbon to decrease.

Part 3: Homework

If you complete the group work, you may work on the homework on your own. This means your answers should be generally unique from other students' answers. **Submit your homework using ANGEL.**

1. Describe what it means for a reservoir to change size.
2. Describe a situation where the residence time for a reservoir in the carbon cycle is **increased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
3. Describe a situation where the residence time for a reservoir in the carbon cycle is **decreased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
4. How does an atom of carbon move from coal into the atmosphere? Explain what would happen to Earth's temperature if the processes that move carbon into the atmosphere slowed down.
5. Recall our earlier work with ocean acidification. How does an atom of carbon move from CO₂ in water into rock? How would an increase in the processes that move carbon into rock impact Earth's temperature?
6. Just for fun: How does an atom of carbon move from HCO₃ in water into carbon in your skin?

6

Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	Ocean, glaciers, ground water, streams	Atmosphere (carbon dioxide) Lithosphere (limestone) Ocean (calc. & CO ₂ , H ₂ O) Biomass/soils, organic carbon
Processes	evaporation, condensation, precipitation, discharge, sublimation, infiltration	Degassing, burial, ocean acidification Photosynthesis, respiration, humans
Residence Times	lower res. time: lower amount of water in res., increase in flow and outflow	same as

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs: a place where material is stored.
2. Evaporation: water turning into vapor from a reservoirs.
3. Degassing: ~~gas~~ moving CO₂ to another reservoirs.
4. Chemical Energy (when is energy used and when is energy released?)
ex. of chemical energy would be burning wood and the release of CO₂ into the atmosphere.

6

Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	Oceans	atmosphere
Longest Residence Time	same as carbon	same as water
Which is more important for driving processes, gravitational or chemical energy?	gravitational	chemical
How are evaporation and degassing SIMILAR?	the both add carbon to different reservoirs, the both are in gas form, starts as water first.	
How are evaporation and degassing DIFFERENT?	degassing adds carbon into different reservoirs and that can sometimes be a bad thing and evaporation is to water	

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Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

a. How would this uplift impact the residence time of CO₂ in the atmosphere?

it would increase the residence time creating more CO₂ into the atmosphere.

b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

the CO₂ speeds up and damages the weathering rate.

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

Glaciers melting increases the melting time and the CO₂ in the atmosphere increase which causes the pH level in the ocean to increase.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

The residence time the atmosphere if decreased will also lower the residence time in the oceans because they have to match.

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Part 3: Homework

If you complete the group work, you may work on the homework **on your own**. This means your answers should be generally unique from other students' answers. **Submit your homework using ANGEL.**

1. Describe what it means for a reservoir to change size.
2. Describe a situation where the residence time for a reservoir in the carbon cycle is **increased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
3. Describe a situation where the residence time for a reservoir in the carbon cycle is **decreased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
4. How does an atom of carbon move from coal into the atmosphere? Explain what would happen to Earth's temperature if the processes that move carbon into the atmosphere slowed down.
5. Recall our earlier work with ocean acidification. How does an atom of carbon move from CO₂ in water into rock? How would an increase in the processes that move carbon into rock impact Earth's temperature?
6. Just for fun: How does an atom of carbon move from HCO₃ in water into carbon in your skin?

ISP203A – Global Change
Cycles

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Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

-Carbon is an element (not a compound like H₂O)

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Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	Ocean, stream, lakes, glaciers, clouds (atmosphere), groundwater (soil)	atmosphere (CO_2, CH_4), ocean ($\text{CaCO}_3, \text{CO}_2, \text{HCO}_3, \dots$), biomass (sugars, organic carbon), lithosphere (limestone $\rightarrow \text{CaCO}_3$, coal, oil, gas)
Processes	evaporation, condensation, precipitation, discharge, transpiration, sublimation, infiltration (recharge)	degassing, burial, ocean acidification, photosynthesis/respiration, weathering, human processes: cement, burning fossil fuels
Residence Times	Lower RT: lower amount of water in reservoir, inflow/outflow increase	more or less the same the water cycle

Part 2: Group Work

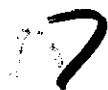
Make sure everyone in your group understands these terms before moving on.

1. Reservoirs: bodies that contain water in any of the three forms

2. Evaporation: changing water to a gaseous state

3. Degassing: moving carbon to a different reservoir

4. Chemical Energy (when is energy used and when is energy released?)
Chemical energy is an energy used to change matter into a different state.



Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	atmosphere because there is much more room in the atmosphere than for each kind of body of water on the ground	atmosphere b/c there is more carbon dioxide in it than each of the other reservoirs.
Longest Residence Time	groundwater b/c it takes 10,000 years	burial
Which is more important for driving processes, gravitational or chemical energy?	gravitational energy because it keeps the cycle moving (compounds) both are important	chemical energy because the carbon is changed into different forms through the process (element)
How are evaporation and degassing SIMILAR?	both break down bonds and put them in the atmosphere	
How are evaporation and degassing DIFFERENT?	evaporation takes liquids and puts it in the atmosphere degassing breaks down CO ₂	



Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

a. How would this uplift impact the residence time of CO_2 in the atmosphere?

It would decrease the residence time of CO_2 in the atmosphere

b. Significantly more CO_2 exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO_2 on the weathering rate of rocks found in mountains, monuments, and bricks? the rocks weather at a faster rate then previously.

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO_2 throughout the entire Earth system.

The amount of water in the ocean decreases due to a major drought. This means that the outflow of water decreases meaning that the residence time would be lowered.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO_2 throughout the entire Earth system.

As in the example above where a large chunk of continental lithosphere uplifts making a huge mountain range. This would increase the R.T.



Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

GROUP #: 8
Student IDs of Members Present:
 A39223581
 A40833474 A43866027
 A42311768

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	Ocean, lakes, streams, glaciers, clouds, groundwater	Atmosphere, ocean, biomass, lithosphere
Processes	evaporation, precipitation, Condensation, discharge, recharge, sublimation	degassing, burial, ocean acidification, photosynthesis, respiration, weathering
Residence Times	lower residence time → lower amount of water	SAME AS water cycle

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs: where a material is held
2. Evaporation: liquid turning into a gas
3. Degassing: CO_2 moving from the ocean to the atmosphere
4. Chemical Energy (when is energy used and when is energy released?)
 used when bonds are broken and released when they're formed

Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	Ocean	Atmosphere
Longest Residence Time	Groundwater	Burial
Which is more important for driving processes, gravitational or chemical energy?	Gravitational energy	Chemical energy
How are evaporation and degassing SIMILAR?	Both evaporation and degassing are breaking down a molecule and into the atmosphere.	
How are evaporation and degassing DIFFERENT?	Evaporation is breaking down liquid into a gas where as degassing is breaking down CO ₂ into the atmosphere from the ocean.	

4

Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

a. How would this uplift impact the residence time of CO₂ in the atmosphere?

Increase because there would be more CO₂ in the atmosphere

b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

The increase in CO₂ in the atmosphere will cause an increase in weathering on these products

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

The lithosphere increases by plate tectonic activity which would increase the amount of limestone causing an increase in the residence time of CO₂.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

If limestone is uplifted from the lithosphere, it would weather and decrease the residence time of CO₂.

9

Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

GROUP #: 9
Student IDs of Members Present:
A40786055
A40680269
A43834997

A41650757 ~~Desiree Herman~~

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	ocean, rivers, streams glaciers, lakes, clouds	atmosphere, ocean (CaCO_3 , CO_2) biosphere (biomass \rightarrow sugars, org, carbon) lithosphere (solid limestone)
Processes	evaporation, condensation precipitation, discharge, sublimation, infiltration	degassing (CO_2), burial ocean acidification, photosynthesis humans
Residence Times	lower residence time, lower amt of water in reservoir inflow + outflow up	more or less the same

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs: Storage places for water or carbon

2. Evaporation: Water from its state in ^{liquid} water to a gas
with increased thermal energy.

3. Degassing: Degassing is when CO_2 moves from a gas in the
ocean to CO_2 gas in the atmosphere

4. Chemical Energy (when is energy used and when is energy released?)

Energy is released when bonds between molecules are broken and it is
used when matter changes.

9

Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	Ocean	Lithosphere Biosphere → living + dead
Longest Residence Time	Residence times are the same across cycles.	
Which is more important for driving processes, gravitational or chemical energy?	Both are equally important in water cycle. Chemical changes help water change state and gravitational helps water move through the cycle (runoff, precipitation)	Chemical because bonds between molecules have to be formed + re-formed
How are evaporation and degassing SIMILAR?	They both involve molecules leaving a reservoir and entering the atmosphere.	
How are evaporation and degassing DIFFERENT?	Evaporation involves a change of state and degassing allows CO_2 to remain in a gaseous state.	

9

Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

a. How would this uplift impact the residence time of CO₂ in the atmosphere?

The residence time would increase.

b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

They would weather faster because there is more carbon in the atmosphere.

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

If we could increase the size of the atmosphere, it will increase the time CO₂ spends in the atmosphere (increased residence time). If we were to make a reservoir smaller, the CO₂ would spend less time in that reservoir. Changing the size could make the cycle go faster or slower.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

If more CO₂ had a longer residence time in the atmosphere, this would allow for more CO₂ to remain in the air and it would onset the greenhouse effect to an extreme amount.

Group #10

ISP203A – Global Change
Cycles

Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	Ocean, Glacier, lakes, Streams, atmosphere, Groundwater	Atmosphere (CO_2 , CH_4) calcium carbonate, CO_2 in ocean ... Limestone
Processes	Evaporation, condensation, precipitation, discharge, sublimation, infiltration	Degassing, burial, ocean acid weathering, humans mine cement
Residence Times	Lower residence time, lower amount in reservoir	pretty much the same

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs: A reservoir is a supply of water, can be anything from an ocean to water in atmosphere.
2. Evaporation: A type of vaporization of liquid, that occurs on surface of liquid.
3. Degassing: Removal of dissolved gases from liquids
4. Chemical Energy (when is energy used and when is energy released?)
Part of energy in process that can be released by chemical reaction.

10

Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	Oceans	CO ₂
Longest Residence Time	Oceans Glaciers	CO ₂ in ocean Calcium carbonate
Which is more important for driving processes, gravitational or chemical energy?	Gravitational	Chemical
How are evaporation and degassing SIMILAR?	Both processes deal with gases and transformation processes.	
How are evaporation and degassing DIFFERENT?	Evaporation deals with water evaporating while degassing deals with removing gas from water.	

16

Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

- a. How would this uplift impact the residence time of CO₂ in the atmosphere?

It would increase the residence time in the atmosphere because there would be more carbon.

- b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

More CO₂ will increase weathering to these rocks and monuments.

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

If there's less carbon in the atmosphere there will be more in the ocean and create a different residence time.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

Carbon is affected in the rivers, lakes, oceans, ect from the changes in carbon levels. This has an impact on all other reservoirs. When a reservoir is impacted so is residence time.

16

Part 3: Homework

If you complete the group work, you may work on the homework on your own. This means your answers should be generally unique from other students' answers. **Submit your homework using ANGEL.**

1. Describe what it means for a reservoir to change size.
2. Describe a situation where the residence time for a reservoir in the carbon cycle is **increased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
3. Describe a situation where the residence time for a reservoir in the carbon cycle is **decreased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
4. How does an atom of carbon move from coal into the atmosphere? Explain what would happen to Earth's temperature if the processes that move carbon into the atmosphere slowed down.
5. Recall our earlier work with ocean acidification. How does an atom of carbon move from CO₂ in water into rock? How would an increase in the processes that move carbon into rock impact Earth's temperature?
6. Just for fun: How does an atom of carbon move from HCO₃ in water into carbon in your skin?

31

11

Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	ocean, lake, ground, clouds, streams	atmosphere, oceans, shells,
Processes	evaporation, condensation, precipitation	
Residence Times		

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs: something that can hold water
2. Evaporation: liquid turning into a gas
3. Degassing: when gases in magma are released and the magma becomes less dense and moves towards the surface.
4. Chemical Energy (when is energy used and when is energy released?)
Chemical Energy is used when bonds are formed and released when they are broken.

Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	Ocean the biggest	atmosphere CO ₂ , CH ₄
Longest Residence Time	Ocean the biggest	Ocean the biggest
Which is more important for driving processes, gravitational or chemical energy?	gravitational because of precipitation	chemical carbon can be made into a compound
How are evaporation and degassing SIMILAR?	they are all about bonds breaking	
How are evaporation and degassing DIFFERENT?	Evaporation has to do w/ the water cycle Degassing has to do w/ the carbon cycle	

Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

- a. How would this uplift impact the residence time of CO_2 in the atmosphere?

The uplift would increase the residence time of CO_2 in the atmosphere. Because there is more CO_2 exposed, it will take longer for the carbon to go through the cycle.

- b. Significantly more CO_2 exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO_2 on the weathering rate of rocks found in mountains, monuments, and bricks?

The added CO_2 in the atmosphere increases the rate at which weathering occurs. The more CO_2 in the atmosphere, the more weathered objects are.

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO_2 throughout the entire Earth system.

The amount of oil drilled out of the ground decreases the size of the reservoir and decrease the residence time of the carbon.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO_2 throughout the entire Earth system.

If we weren't to drill oil, the residence time of CO_2 would be increased because the ~~size~~ size of the reservoir would be increased.

12

Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

GROUP #:

Student IDs of Members Present:

A40920866

A43365634

A43506836

A43272425

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	Ocean, glaciers, lakes, streams, clouds, groundwater	Lithosphere: limestone, coal/oil/gas Atmosphere: carbon dioxide, methane Oceans: calcium carbonate, carbon dioxide (gas) Biosphere: sugars, organic carbon
Processes	Evaporation, condensation, precipitation, discharge, sublimation	Degassing, Burial, ocean acidification, photosynthesis, respiration, weathering
Residence Times	lower amt of H ₂ O = ↓ res time ↑ inflow/outflow = ↓ res time	more or less the same

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs:

A storage point for sources of water
(ie streams, clouds, etc.)

2. Evaporation:

When water from one reservoir loses density, becomes a gas, and moves to a different reservoir

3. Degassing:

movement of gases between atmosphere and hydrosphere – balances energy. ocean → atmosphere
Carbon dioxide moves from ocean

4. Chemical Energy (when is energy used and when is energy released?)

The addition or subtraction of ions/atoms to any given substance (ie carbon added to a compound)



12

Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	Glaciers - longest residence time	Atmosphere - All carbon on Earth/Ocean balances w/ atmosphere
Longest Residence Time	Glaciers - Biggest reservoir	Lithosphere - carbon is in a harder form to chemically deconstruct
Which is more important for driving processes, gravitational or chemical energy?	Gravitational: Density changes push the cycle along	chemical: Addition/subtraction of more carbon from various compounds
How are evaporation and degassing SIMILAR?	Evaporation and degassing both move substances from one reservoir to a new atmospheric reservoir.	
How are evaporation and degassing DIFFERENT?	Evaporation changes the density of a substance whereas degassing changes the chemical makeup	



Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

a. How would this uplift impact the residence time of CO_2 in the atmosphere?

Residence time in the atmosphere would increase since CO_2 between the atmosphere and hydrosphere always stays balanced. This means the more CO_2 in the oceans/streams the more in the air.

b. Significantly more CO_2 exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO_2 on the weathering rate of rocks found in mountains, monuments, and bricks?

The weathering rate increases because of the acidity of rain is higher.

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO_2 throughout the entire Earth system.

If more calcium carbonate collects in the ocean in shell form then residence time decreases since an increased carbon input decreases res. time.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO_2 throughout the entire Earth system.

If ~~more~~ oil/coal is taken out of burial and actually utilized then the residence time in other reservoirs will decrease since an increased outflow from the oil/coal reservoir lowers res. time overall.

Part 3: Homework

If you complete the group work, you may work on the homework **on your own**. This means your answers should be generally unique from other students' answers. **Submit your homework using ANGEL.**

1. Describe what it means for a reservoir to change size.
2. Describe a situation where the residence time for a reservoir in the carbon cycle is **increased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
3. Describe a situation where the residence time for a reservoir in the carbon cycle is **decreased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
4. How does an atom of carbon move from coal into the atmosphere? Explain what would happen to Earth's temperature if the processes that move carbon into the atmosphere slowed down.
5. Recall our earlier work with ocean acidification. How does an atom of carbon move from CO₂ in water into rock? How would an increase in the processes that move carbon into rock impact Earth's temperature?
6. Just for fun: How does an atom of carbon move from HCO₃ in water into carbon in your skin?

Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes



GROUP #: **13**
Student IDs of members Present:
A43819247 - [redacted]
A42096024 - [redacted] and
A42957208 - [redacted]

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs		
Processes		
Residence Times		

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs:

2. Evaporation:

3. Degassing:

4. Chemical Energy (when is energy used and when is energy released?)

ISP203A – Global Change
Cycles

Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	Oceans and atmosphere	Atmosphere and lithosphere
Longest Residence Time	Oceans and glaciers	Lithosphere
Which is more important for driving processes, gravitational or chemical energy?	gravitational	Chemical
How are evaporation and degassing SIMILAR?	Both are coming from oceans to atmosphere	
How are evaporation and degassing DIFFERENT?	The substances differ, degassing deals with carbon and evaporation deals with H_2O	

Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

- a. How would this uplift impact the residence time of CO_2 in the atmosphere?

It would put more CO_2 into the atmosphere, thus increasing the residence time.

- b. Significantly more CO_2 exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO_2 on the weathering rate of rocks found in mountains, monuments, and bricks?

Higher CO_2 rates have led to higher acidification rates on rocks.

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO_2 throughout the entire Earth system.

By taking oil out of the ground and burning it we increase residence time of CO_2 in the atmosphere.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO_2 throughout the entire Earth system.

The more CO_2 we put into the atmosphere, the longer the residence time of CO_2 in the atmosphere. The more CO_2 in the atmosphere, the more CO_2 is pushed into the oceans, increasing the residence time of CO_2 in ~~ocean~~ oceans.

Part 3: Homework

If you complete the group work, you may work on the homework on your own. This means your answers should be generally unique from other students' answers. **Submit your homework using ANGEL.**

1. Describe what it means for a reservoir to change size.
2. Describe a situation where the residence time for a reservoir in the carbon cycle is **increased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
3. Describe a situation where the residence time for a reservoir in the carbon cycle is **decreased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
4. How does an atom of carbon move from coal into the atmosphere? Explain what would happen to Earth's temperature if the processes that move carbon into the atmosphere slowed down.
5. Recall our earlier work with ocean acidification. How does an atom of carbon move from CO₂ in water into rock? How would an increase in the processes that move carbon into rock impact Earth's temperature?
6. Just for fun: How does an atom of carbon move from HCO₃ in water into carbon in your skin?

Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs (Storage)	Ocean, glacier, lakes, streams, clouds, soil groundwater	atmosphere (CO_2 , CH_4) condens , ocean (CaCO_3 , CO_2 , CH_4) biomass (sugars, organic)
Processes	evaporation, condensation, precipitation, discharge, ^{transpiration} sublimation, recharge	degassing, burial, ocean acidification, photosynthesis, respiration, weathering
Residence Times	lower: less water inflow + outflow up	\Rightarrow same

lithosphere
(limestone,
 CaCO_3 , coal, oil,
gas)

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs:

Storage for bodies of water (lake, pond, river, etc.)

2. Evaporation:

The process in which a liquid becomes a gas.

3. Degassing:

When molecules move = emissions of gases

4. Chemical Energy (when is energy used and when is energy released?)

The energy produced when bonds are
broken, ~~used~~

The energy used when bonds are formed.

14

Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	glacier, ocean, atmosphere	atmosphere ocean
Longest Residence Time	ocean	ocean
Which is more important for driving processes, gravitational or chemical energy?	gravitational (both)	chemical (both)
How are evaporation and degassing SIMILAR?	They both involve molecules moving	
How are evaporation and degassing DIFFERENT?	evap. is molecules changing <u>state</u> degassing is molecules moving	

14

Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

a. How would this uplift impact the residence time of CO₂ in the atmosphere?

It would lengthen due to more carbon

b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

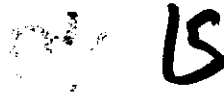
The more CO₂ in atmosphere causes
more melting on the rocks

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

Changing one element in the cycle
(~~lithosphere~~ ~~ocean~~ ~~glaciers~~) changes every other
element (ocean, atmosphere, etc.)

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

It is the same as above because RT
changes when the size of a reservoir
changes



Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

21 15

GROUP #: 15
Student IDs of Members Present:
A41021960 - ~~021021961~~

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	Ocean, glaciers, lakes, streams, clouds	Atmosphere, oceans, biomass, Lithosphere, limestone
Processes	Evaporation, condensation, precipitation, discharge, sublimation, infiltration	degassing, burial, ocean acid, photosynthesis, respiration, weathering
Residence Times	lower residence time, lower amount of water in reservoir, inflow and outflow up.	same.

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs:

Storage of a certain thing (water, carbon). has inflow / outflow

2. Evaporation:

liquid water is evaporating into the atmosphere and turning into gas.

3. Degassing:

4. Chemical Energy (when is energy used and when is energy released?)

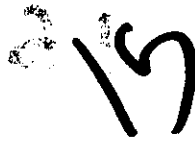
Energy is released when bonds formed and used when bonds break apart

21.5

Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	Oceans	Lithosphere (limestone)
Longest Residence Time	Oceans	Lithosphere
Which is more important for driving processes, gravitational or chemical energy?	gravitational	chemical
How are evaporation and degassing SIMILAR?	They are both changing the chemical composition of something.	
How are evaporation and degassing DIFFERENT?	Evaporate	



Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

- a. How would this uplift impact the residence time of CO₂ in the atmosphere?

increase carbon dioxide
into the atmosphere
increase residence time

- b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

increase because the
more CO₂ increases
weathering

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

New mountain ranges that form. this increases
the amount of carbon dioxide into atmosphere.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

16
GROUP #: 16
Student IDs of Members Present:
H409747019
A431451662
A37417903

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	Ocean, glaciers, lakes, Streams, clouds (atmosphere) groundwater (soil)	atmosphere (CO_2 , CH_4) Oceans (CaCO_3 , CO_2 , H_2O ...) biomass (sugars, organic carbon) lithosphere (limestone - CaCO_3 , coal, oil, gas)
Processes	Evaporation, condensation, precipitation, discharge, transpiration sublimation, infiltration (recharge)	degassing - burial, Ocean-acid photosynthesis, respiration, weathering
Residence Times	lower residence time, lower amount of water in reservoirs, inflow and outflow up	more or less the same

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs:

a place where water is stored

2. Evaporation:

liquid to gas

3. Degassing:

Carbon^{dioxide} moving from Ocean to atmosphere

4. Chemical Energy (when is energy used and when is energy released?)

Energy used to break bonds

Released when bonds are formed

Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	Oceans -	Oceans
Longest Residence Time	Ocean	Lithosphere
Which is more important for driving processes, gravitational or chemical energy?	gravitational pulls water from one reservoir to the next chemical also important	Chemical is important because Carbon forms so many bonds. Gravitational also important
How are evaporation and degassing SIMILAR?	Carbon dioxide and water enter Atmosphere	
How are evaporation and degassing DIFFERENT?	evaporation is the transpiration from liquid to gas degassing - Carbon is gas in both in Ocean and Atmosphere	

16

Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

- a. How would this uplift impact the residence time of CO₂ in the atmosphere?

It would decrease because inflow and out flow would increase/speed up

- b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

Increased weathering due to acidification (eg acid rain eats away at exposed rock)

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

Decreasing the size of a limestone reservoir which will decrease individual residence times despite overall increase of CO₂ in other reservoirs

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

Forest clearing → decreases residence time in biomass - increases inflow into other reservoirs such as the atmosphere and oceans

Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	Ocean, Glaciers, lakes, streams, atmosphere, groundwater	Atmosphere (CO ₂ , CH ₄), Carbon in rocks, CO ₂ in ocean, Limestone
Processes	Evaporation, condensation, precipitation, discharge, sublimation, infiltration	Respiration, burial, ocean acid weathering, humans make cement
Residence Times	Lower residence time, lower amount in reservoir	Pretty much the same

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs: A reservoir is a supply of water, can be anything from an ocean to water in atmosphere.
2. Evaporation: A type of vaporization of liquid, that occurs on surface of liquid.
3. Degassing: Removal of dissolved gases from liquids.
4. Chemical Energy (when is energy used and when is energy released?)
Part of energy in process that can be released by chemical reaction.

17

Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	Oceans	CO ₂
Longest Residence Time	Oceans Glaciers	CO ₂ in the ocean Calcium carbonate
Which is more important for driving processes, gravitational or chemical energy?	Gravitational	Chemical
How are evaporation and degassing SIMILAR?	They both involve transfer of gases	
How are evaporation and degassing DIFFERENT?	Degassing takes gases out of liquid but evaporation is water forming into gas	



Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

- a. How would this uplift impact the residence time of CO₂ in the atmosphere?

The residence time would increase because there is more carbon.

- b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

More CO₂ would increase weathering

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

There is less carbon in the atmosphere thus increasing the carbon in the ocean.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

Carbon is affected in the bodies of water. This impacts all other reservoirs.

Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	Ocean, lakes, streams, clouds (Atmosphere), Ground water (Soil)	Atmosphere (CO_2 , CH_4) oceans (CaCO_3 , CO_2 , HCO_3^- ...) biomass (Sugars organic C)
Processes	Evaporation, Condensation, Precipitation, discharge, Sublimation, Intrication (seepage)	Degassing, burial, ocean acid, Photosynthesis, respiration, weather, (humans: burning fossil fuels)
Residence Times	Lower residence time: lower amount of water in reservoirs. reservoir: Inflow and outflow	More or less the same

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs:

over Point in a cycle where whatever is flowing slows down and has residence time: kept in store

2. Evaporation:

Process where liquid water becomes gaseous water due to heat

3. Degassing:

Removal or dissolved gases from liquids

4. Chemical Energy (when is energy used and when is energy released?)

Chemical energy is ~~retained~~ ~~from~~ released when bonds are formed then when these bonds break twice when that energy is used.

19

Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	Ocean	Limestone
Longest Residence Time	Ocean Glaciers	Limestone
Which is more important for driving processes, gravitational or chemical energy?	All of the energy is Incredibly Important because without one part of energy there is no the cycle is Broken	Chemical Thermal
How are evaporation and degassing SIMILAR?	In both Processes water and gas are being moved into the Atmosphere	
How are evaporation and degassing DIFFERENT?	They are opposite one involves removing gases from a liquid while the other changes a liquid into a gas.	

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Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

- a. How would this uplift impact the residence time of CO₂ in the atmosphere?

Eventually that carbon will ~~be~~ make its way into water then to the air where it would remain a greenhouse gas for a while

- b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

It is just added CO₂ to the Atmosphere more acid rain and more greenhouse gases in the Atmosphere

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

The reservoir of the lithosphere increased so there are more materials like limestone in the ground and because humans are the only things that will remove it it will seriously increase the speed in which those burn.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

See previous question.

ISP203A – Global Change
Cycles

Part 3: Homework

If you complete the group work, you may work on the homework **on your own**. This means your answers should be generally unique from other students' answers. **Submit your homework using ANGEL.**

1. Describe what it means for a reservoir to change size.
2. Describe a situation where the residence time for a reservoir in the carbon cycle is **increased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
3. Describe a situation where the residence time for a reservoir in the carbon cycle is **decreased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
4. How does an atom of carbon move from coal into the atmosphere? Explain what would happen to Earth's temperature if the processes that move carbon into the atmosphere slowed down.
5. Recall our earlier work with ocean acidification. How does an atom of carbon move from CO₂ in water into rock? How would an increase in the processes that move carbon into rock impact Earth's temperature?
6. Just for fun: How does an atom of carbon move from HCO₃ in water into carbon in your skin?

Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes



GROUP #: 19
Student IDs of Members Present:
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A40212800
A40749278

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	WHERE WATER IS STORED - LAKES - GLACIERS - OCEANS - AIR - RIVERS - GLACIERS	WHERE CARBON IS STORED - ATMOSPHERE (CO_2 , CH_4) - OCEANS (CaCO_3 , CO_2 , HCO_3^-) - BIOMASS (PLANTS, ANIMALS, DEBRIS)
Processes	- EVAPORATION - CONDENSATION - TRANSPIRATION - RECHARGE - DISCHARGE - SUBSISTANCE	DEGASSING, BURIAL, OCEAN ACIDIFICATION, PHOTOSYNTHESIS + RESPIRATION
Residence Times	- LOWER OR RAISE AMOUNT OF WATER. - IN & OUTFLOW OR OUTFLOW	MOVE OR LOSS THE SAME.

LITHOSPHERE
(LIVESTONE - CARBON)

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs:

WHERE WATER IS STORED / HOLD.

2. Evaporation:

ALLOWING MOLECULES TO BREAK BOND OF MOLECULES TO ALLOW FOR A CHANGE IN WATER.

3. Degassing:

PROCESS OF WHICH CARBON IS RELEASED.

4. Chemical Energy (when is energy used and when is energy released?)

Chemical energy is released when bonds are broken (AND THE
BONDING IS RELEASED WHEN THE BOND IS
BROKEN).

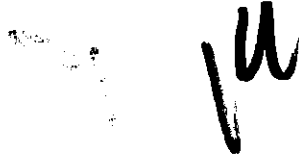
19

Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	OCEANS. COVER MOST OF THE EARTH.	ATMOSPHERE (?) LITHOSPHERE BIOSPHERE
Longest Residence Time	INFLOW VS. OUTFLOW. INFLOW ↑, OUTFLOW ↓, RESIDENCE TIME ↑ GROUNDWATER.	INFLOW VS. OUTFLOW. ROCKS.
Which is more important for driving processes, gravitational or chemical energy?	BOTH EQUALLY IMPORTANT. G = EVAPORATION, INFILTRATION, PRECIPITATION C = CONDENSATION, PRECIPITATION, EVAPORATION, ETC.	GRAVITATIONAL BECAUSE CARBON IS NOT CHANGING PHASE. IT REMAINS IN A GASEOUS STATE.
How are evaporation and degassing SIMILAR?	BOTH RELEASE SOMETHING INTO THE ATMOSPHERE. MORE HEAT = MORE EVAPORATION ↓ MORE DEGASSING	
How are evaporation and degassing DIFFERENT?	EVAPORATION = PHASE & MATERIAL CHANGES (LIQUID TO GAS) DEGASSING = NO PHASE CHANGES. GAS (CO ₂) LEAVING & REMAINING.	

→ LIMESTONES.



Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

a. How would this uplift impact the residence time of CO₂ in the atmosphere?

IT WOULD INCREASE THE RESIDENCE TIME, BECAUSE
INFLOW IS INCREASING & OUTFLOW REMAINS THE SAME.

b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

IT HAS

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.
3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

Part 3: Homework

If you complete the group work, you may work on the homework **on your own**. This means your answers should be generally unique from other students' answers. **Submit your homework using ANGEL.**

1. Describe what it means for a reservoir to change size.
2. Describe a situation where the residence time for a reservoir in the carbon cycle is **increased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
3. Describe a situation where the residence time for a reservoir in the carbon cycle is **decreased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
4. How does an atom of carbon move from coal into the atmosphere? Explain what would happen to Earth's temperature if the processes that move carbon into the atmosphere slowed down.
5. Recall our earlier work with ocean acidification. How does an atom of carbon move from CO₂ in water into rock? How would an increase in the processes that move carbon into rock impact Earth's temperature?
6. Just for fun: How does an atom of carbon move from HCO₃ in water into carbon in your skin?

20

Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	oceans, glaciers, lakes, streams, clouds, atmosphere, groundwater	atmosphere (CO_2 , CH_4), oceans (CaCO_3 , CO_2 , HCO_3^-), biomass (sugars, organic carbon), lithosphere (limestone - CaCO_3)
Processes	evaporation, condensation, precipitation, discharge, sublimation, infiltration (recharge), transpiration	degassing, burial, ocean acidification, photosynthesis, respiration, weathering of rocks
Residence Times	lower RT: lower amount of water in reservoir	more or less the same

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs:

stores/holds an element, like water in the water cycle

2. Evaporation:

changes liquid water to gas using thermal energy

3. Degassing:

gas leaving liquids

4. Chemical Energy (when is energy used and when is energy released?)

20

Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	oceans	limestone
Longest Residence Time	groundwater	lithosphere
Which is more important for driving processes, gravitational or chemical energy?	gravitational	chemical
How are evaporation and degassing SIMILAR?	In both evaporation and degassing gas is released and bonds are broken, so they move faster.	
How are evaporation and degassing DIFFERENT?	Evaporation is changing the state of water from liquid to gas. But, degassing is releasing a gas from a liquid.	

20

Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

- a. How would this uplift impact the residence time of CO₂ in the atmosphere?

It would increase the residence time. If we weather rocks, we put more CO₂ in the atmosphere, this increases the residence time.

- b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

The added CO₂ would increase the weathering rate of rocks. Weathering produces more CO₂ which produces more weathering, this is a positive feedback.

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

Part 3: Homework

If you complete the group work, you may work on the homework on your own. This means your answers should be generally unique from other students' answers. **Submit your homework using ANGEL.**

1. Describe what it means for a reservoir to change size.
2. Describe a situation where the residence time for a reservoir in the carbon cycle is **increased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
3. Describe a situation where the residence time for a reservoir in the carbon cycle is **decreased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
4. How does an atom of carbon move from coal into the atmosphere? Explain what would happen to Earth's temperature if the processes that move carbon into the atmosphere slowed down.
5. Recall our earlier work with ocean acidification. How does an atom of carbon move from CO₂ in water into rock? How would an increase in the processes that move carbon into rock impact Earth's temperature?
6. Just for fun: How does an atom of carbon move from HCO₃ in water into carbon in your skin?

Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

Carbon cycle / "greenhouse" effect / heat-trapping gases

Breaking chemical bonds requires energy, creating chemical bonds releases energy.

GROUP #: 21
Student IDs of Members Present:
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A42134271
A42052431

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	Oceans, glacial ice, freshwater, atmosphere, groundwater, biosphere	Atmospheric (CO_2 + methane), Oceans (CaCO_3 + CO_2 + HCO_3^-), biosphere (biomass), lithosphere (CaCO_3 , hydrocarbons)
Processes	Evaporation, condensation, precipitation, discharge, sublimation, infiltration, transpiration	Weathering, degassing, erosion, dissolution, burial, photosynthesis
Residence Times	Decrease residence time. Alter flux of water.	Similar residence times

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs:

A component of the climate system which has the capacity to store, accumulate, or release a substance of concern.

2. Evaporation:

The process of a liquid converting to a gaseous state; vaporization.

3. Degassing:

The removal of dissolved gases from liquids, especially water or aqueous solutions.

4. Chemical Energy (when is energy used and when is energy released?)

- Energy is released during the formation of chemical bonds.
- Energy is required to break chemical bonds.

21

Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

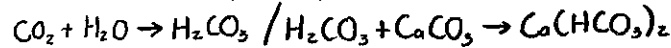
Feature	Water Cycle	Carbon Cycle
Largest Reservoir	Oceans	Lithosphere
Longest Residence Time	Oceans	Lithosphere
Which is more important for driving processes, gravitational or chemical energy?	Gravitational and chemical energy are both important in the hydrologic cycle. Gravitational energy causes the flux of water amongst reservoirs.	Chemical reactions change the substance in which carbon is found. Gravitational energy is important in the burial of carbon.
How are evaporation and degassing SIMILAR?	Evaporation and degassing both involve the introduction of gaseous matter into a reservoir.	
How are evaporation and degassing DIFFERENT?	Evaporation is the vaporization of a liquid substance, whereas degassing is the release of a gas.	



Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

- a. How would this uplift impact the residence time of CO₂ in the atmosphere?



Carbonic acid found naturally in precipitation weathers the lithospheric rock and bicarbonate enters the hydrosphere. Eventually carbon enters the atmosphere.

- b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

More CO₂ in the atmosphere enhances the greenhouse effect. More carbon dioxide also implies larger quantities of carbonic acid.

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

Carbon sequestration is able to impact the flux of carbon dioxide.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

Carbon sequestration is artificial means of changing the quantity of carbon in the atmosphere.

ISP203A – Global Change
Cycles

Part 3: Homework

If you complete the group work, you may work on the homework on your own. This means your answers should be generally unique from other students' answers. **Submit your homework using ANGEL.**

1. Describe what it means for a reservoir to change size.
2. Describe a situation where the residence time for a reservoir in the carbon cycle is **increased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
3. Describe a situation where the residence time for a reservoir in the carbon cycle is **decreased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
4. How does an atom of carbon move from coal into the atmosphere? Explain what would happen to Earth's temperature if the processes that move carbon into the atmosphere slowed down.
5. Recall our earlier work with ocean acidification. How does an atom of carbon move from CO₂ in water into rock? How would an increase in the processes that move carbon into rock impact Earth's temperature?
6. Just for fun: How does an atom of carbon move from HCO₃ in water into carbon in your skin?

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	Oceans, glacier, lake, stream, cloud (atmosphere), ground water	atmosphere (CO_2 , CH_4), Ocean (CaCO_3 , CO_2), Biosphere/mass (aggrs), organic carbon, lithosphere (limestone) CaCO_3
Processes	transpiration, evaporation, condensation, precipitation, discharge, sublimation, infiltration	Degassing, burial, ocean acidification, photosynthesis, respiration, weathering
Residence Times	longer RT: lower amount of water in reservoir. Inflow + outflow up	More or less the same

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs:

Where a certain substance is stored whether it is water, oil, or CO_2

2. Evaporation:

Water rising into the atmosphere & being stored in the form of clouds

3. Degassing:

The release of gases from liquids (like water)

4. Chemical Energy (when is energy used and when is energy released?)

The energy used for a chemical transformation, energy is used when bonds must be broken & is released when bonds are formed

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Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

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Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	Atmosphere	Atmosphere
Longest Residence Time	water Ocean because has the largest body of water	Ocean because it longer to break down go through the process. Limestone
Which is more important for driving processes, gravitational or chemical energy?	both	Chemical
How are evaporation and degassing SIMILAR?	They are similar because they both have to do with the atmosphere	
How are evaporation and degassing DIFFERENT?	Evaporation is when a liquid turns to a gas. and degassing is when the removal of gasses from a liquid.	

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A42831439

A42829869

A37669797

A41729348

Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

a. How would this uplift impact the residence time of CO₂ in the atmosphere?

Residence time would decrease because the rate of CO₂ flow would increase, & according to the res. time equation, the time is inversely proportional to the rate of flow, so as the rate of flow increases, the time decreases.

b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

The added CO₂ has increased the weathering rate of rocks because there's more CO₂ to react w/ water to create the acids w/ eventually after dissociating react w/ minerals to cause the weathering effect.

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

If there were to be more rocks (limestone) in the atmosphere the weathering process would take a long time to react with the acid & water, which effects the entire system.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

The atmosphere would be an example of this because when the residence time is a long length, it throws off the cycle of going through the ocean.

Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

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GROUP #: 23
Student IDs of Members Present:
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Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle ^{Many forms}
Reservoirs	ocean, lake, ground, etc.,...	atm (CO_2 , CH_4) ocean (CaCO_3 , CO_2 , HCO_3^-) limestone
Processes	Fluxes, evaporation, runoff, etc.,...	degassing, burial, ocean acid, photosynth.
Residence Times	depends on amt in reservoir	

↑ inflow/outflow, ↓ RT

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs:

a place where something is held.
ex) ocean: water & carbon are both held here

2. Evaporation:

when liquid turns to gas

3. Degassing:

when CO_2 moves from the ocean to the atmosphere

4. Chemical Energy (when is energy used and when is energy released?)

energy is used when bonds are broken
& released when bonds are formed

Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	glaciers	rocks
Longest Residence Time	oceans	same
Which is more important for driving processes, gravitational or chemical energy?	gravitational	chemical
How are evaporation and degassing SIMILAR?	both evolve gases being released into the atm	
How are evaporation and degassing DIFFERENT?	evaporation causes water to change states forms , degassing moves CO ₂ but doesn't change forms states	

$$RT = \frac{amt}{flow}$$

Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

a. How would this uplift impact the residence time of CO₂ in the atmosphere?

this would increase degassing, which increases flow of CO₂ into atm therefore decreasing RT.

b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

the rapid change in temp. causes rocks to crack, increasing weathering.

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

more fossil fuels being burnt increases the amount of CO₂ in the atm. This decreases the RT.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

If the residence time for CO₂ in the ocean is increased, then the residence time of CO₂ in the atmosphere will decrease.

ISP203A – Global Change
Cycles

Part 3: Homework

If you complete the group work, you may work on the homework on your own. This means your answers should be generally unique from other students' answers. **Submit your homework using ANGEL.**

1. Describe what it means for a reservoir to change size.
2. Describe a situation where the residence time for a reservoir in the carbon cycle is **increased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
3. Describe a situation where the residence time for a reservoir in the carbon cycle is **decreased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
4. How does an atom of carbon move from coal into the atmosphere? Explain what would happen to Earth's temperature if the processes that move carbon into the atmosphere slowed down.
5. Recall our earlier work with ocean acidification. How does an atom of carbon move from CO₂ in water into rock? How would an increase in the processes that move carbon into rock impact Earth's temperature?
6. Just for fun: How does an atom of carbon move from HCO₃ in water into carbon in your skin?

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Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

Ocean acidification

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	ocean, lakes, glaciers, streams, clouds (in atmosphere), ground water.	atmosphere (CO_2 , methane CH_4); oceans (calcium carb CaCO_3 ; CO_2); biomass (sugar, organic carbon); lithosphere (limestone CaCO_3); coal, oil, gas
Processes	evaporation, gas, precipitation, discharge, sublimation, infiltration, or recharge, transpiration.	degassing; burial; ocean acidification; photosynthesis/respiration/metabolism; weathering; (human: - burning fossil fuels)
Residence Times	lower rt, lower water in reservoir increase inflow, outflow decrease rt.	The same as water cycle

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs:

2. Evaporation: indiv. molecular bonds break up - liquid turning into gas

3. Degassing: when CO_2 goes from ocean to atmosphere

4. Chemical Energy (when is energy used and when is energy released?)

transpiration - plants take water from soil & release into atmosphere.

degassing - ocean to atmosphere - CO_2

Decay - release CO_2

ISP203A – Global Change
Cycles

Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir <i>which has more carbon on rock.</i>	<i>ocean / atmosphere</i>	<i>biosphere (living or dead)</i>
Longest Residence Time		
Which is more important for driving processes, gravitational or chemical energy?	<i>gravitational energy</i>	<i>chemical energy.</i>
How are evaporation and degassing SIMILAR?	<i>Evaporation has to do w/ water - it is where H₂O goes from liquid to gas - the bonds b/ molecules are breaking. Degassing - has to do w/ CO₂. When CO₂ goes from ocean into atmosphere.</i>	
How are evaporation and degassing DIFFERENT?	<i>They are both go to atmosphere, & are breaking molecules.</i>	

decay

ISP203A – Global Change
Cycles

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Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

- a. How would this uplift impact the residence time of CO₂ in the atmosphere?

increase CO₂, because when rock weather or decay they release more CO₂. If weathering rock adding CO₂ to atm. more CO₂ in atm.

- b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

If more CO₂ in atmosphere increases weathering b/ CO₂ w/ H₂O cause acid.

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

If the size of a reservoir, atmosphere, changes so does the RT. If RT increase, then CO₂ will decrease, in the Earth system, ~~the Earth system~~, because restricted the outflow.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

If RT for reservoir increases then the resid time of CO₂ throughout Earth system increases as well.

Part 3: Homework

If you complete the group work, you may work on the homework on your own. This means your answers should be generally unique from other students' answers. **Submit your homework using ANGEL.**

1. Describe what it means for a reservoir to change size.
2. Describe a situation where the residence time for a reservoir in the carbon cycle is **increased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
3. Describe a situation where the residence time for a reservoir in the carbon cycle is **decreased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
4. How does an atom of carbon move from coal into the atmosphere? Explain what would happen to Earth's temperature if the processes that move carbon into the atmosphere slowed down.
5. Recall our earlier work with ocean acidification. How does an atom of carbon move from CO₂ in water into rock? How would an increase in the processes that move carbon into rock impact Earth's temperature?
6. Just for fun: How does an atom of carbon move from HCO₃ in water into carbon in your skin?

Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	Ocean Clouds glaciers groundwater streams	Atmosphere (CO_2 , CH_4) Oceans (CaCO_3 , CO_2) HCO_3^- Biomass (sugars, organic carbon)
Processes	evaporation, discharge condensation, precipitation,	Degassing Photosynthesis Burial Respiration Acidification
Residence Times	lower res. time: lower amount in reservoir; inflow and outflow up	more or less the same

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs: Artificial lake that is used to store water until it is needed.
2. Evaporation: process by which water is converted from liquid form to vapor.
3. Degassing: Process by which dissolved gas is removed from water or other liquid solutions.
4. Chemical Energy (when is energy used and when is energy released?)
Potential of a chemical substance to undergo a chemical reaction (released) or to transform chemical substances (used).

2025

Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	Ocean	Atmosphere
Longest Residence Time	Groundwater	Lithosphere
Which is more important for driving processes, gravitational or chemical energy?	Gravitational energy. Ability for denser water to fall and evaporate. Makes water runoff.	Chemical energy. Changes it to different forms (CaCO ₃ , HCO ₃ , CH ₄ , CO ₂)
How are evaporation and degassing SIMILAR?	Substances are being dissolved and moved.	
How are evaporation and degassing DIFFERENT?	Evaporation puts moisture into air Degassing removes water from substance	

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Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

a. How would this uplift impact the residence time of CO₂ in the atmosphere?

weathering produce CO₂
Increase the residence time because there would be more CO₂ in the atmosphere

- b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

The more CO₂ you have the more weathering - Positive Feedback Loop

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

IF the biomass is decreased (trees cut down) the CO₂ would increase and this would increase the residence time.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

In the lithosphere, if an earthquake or volcano release rock and minerals into air this would increase the residence time in atmosphere.

Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

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A42707740
A40850791

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	Oceans, lakes	Atmosphere, oceans
Processes	evaporation, condensation, precipitation, discharge	degassing, Burial, ocean acidification, photosynthesis & respiration
Residence Times	The lower the amount of water in the reservoir	Same as water cycle

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs:

A holding place for a substance such as lakes in the water cycle

2. Evaporation:

The process of liquid becoming a gas.
Very common in water cycle where water from reservoirs evaporates into the atmosphere and eventually condenses.

3. Degassing:

Carbon dioxide as a gas from the hydrosphere becomes CO₂ as a gas in the atmosphere.

4. Chemical Energy (when is energy used and when is energy released?)

Energy is used when bonds ~~break~~^{break} and released when bonds form.

26

Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	Oceans	limestone
Longest Residence Time	Oceans	limestone
Which is more important for driving processes, gravitational or chemical energy?	grav + chemical	grav + chemical
How are evaporation and degassing SIMILAR?	Taking molecules from the hydrophere oceans/lakes, etc. to the atmosphere.	
How are evaporation and degassing DIFFERENT?	evap. is liquid to gas and degassing is gas to gas.	



Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

- a. How would this uplift impact the residence time of CO₂ in the atmosphere?

Increase because carbon from oceans would leak into atmosphere by attaining equilibrium causing a higher inflow in the residence time equation

- b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

Increases weathering rate!

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

Coral reef deteriorating causing more CO₂ to be released in oceans which increases residence time because there is a larger reservoir and more inflow and outflow

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

Burning of fossil fuels releases more CO₂ into atmosphere which increases residence time which in turn increases other residence times.

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Part 3: Homework

If you complete the group work, you may work on the homework on your own. This means your answers should be generally unique from other students' answers. **Submit your homework using ANGEL.**

1. Describe what it means for a reservoir to change size.
2. Describe a situation where the residence time for a reservoir in the carbon cycle is **increased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
3. Describe a situation where the residence time for a reservoir in the carbon cycle is **decreased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
4. How does an atom of carbon move from coal into the atmosphere? Explain what would happen to Earth's temperature if the processes that move carbon into the atmosphere slowed down.
5. Recall our earlier work with ocean acidification. How does an atom of carbon move from CO₂ in water into rock? How would an increase in the processes that move carbon into rock impact Earth's temperature?
6. Just for fun: How does an atom of carbon move from HCO₃ in water into carbon in your skin?

27

Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

Water Cycle

- Thermal drives evaporation, gravitational drives precipitation, etc
- includes reservoirs & processes (fluxes)

Carbon Cycle

- carbon combines to change other elements
 - ↳ may be in other forms
- *be able to process what may happen
- ocean acidification

GROUP #:
Student IDs of Members Present:
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A42669614
A42704999

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	oceans, glaciers, lakes, streams, clouds/ atmosphere, ground water	atmosphere (CO_2, CH_4), oceans ($\text{CaCO}_3, \text{CO}_2, \text{HCO}_3 \dots$), biomass (sugar/organic), lithosphere (CaCO_3)
Processes	evaporation, condensation, precipitation, discharge, sublimation, infiltration, etc	degassing, burial, ocean acidification, photosynthesis, respiration, weathering, humans
Residence Times	lower time = lower amt, inflow & outflow up	(same)

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs:

Body that holds substance (either water or carbon in this case)

2. Evaporation:

Breaking molecules in H_2O to change from liquid to gas

3. Degassing:

When carbon dioxide moves from ocean to atmosphere

4. Chemical Energy (when is energy used and when is energy released?)

Chemical energy is needed to break or form bonds. When bonds are formed energy is used and released when bonds break.

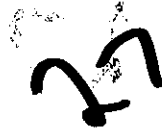
27

Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	Oceans	Oceans
Longest Residence Time	Oceans - larger amt means longer r.t.	Oceans - larger amt means longer r.t.
Which is more important for driving processes, gravitational or chemical energy?	All energies are important because... they all have an effect!	
How are evaporation and degassing SIMILAR?	Both move the substance (carbon or water) from ocean to atmosphere	
How are evaporation and degassing DIFFERENT?	In evaporation, water remains water but changes states. In degassing, carbon changes form	

energy



Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

- a. How would this uplift impact the residence time of CO₂ in the atmosphere?

Amount of CO₂ in atmosphere increases so
res. time increases

- b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

Weathering rates have increased so things break down
faster

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

The size of the reservoir is changed
so residence time changes

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

Residence time in one reservoir affects
the entire system.

Part 3: Homework

If you complete the group work, you may work on the homework on your own. This means your answers should be generally unique from other students' answers. **Submit your homework using ANGEL.**

1. Describe what it means for a reservoir to change size.
2. Describe a situation where the residence time for a reservoir in the carbon cycle is **increased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
3. Describe a situation where the residence time for a reservoir in the carbon cycle is **decreased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
4. How does an atom of carbon move from coal into the atmosphere? Explain what would happen to Earth's temperature if the processes that move carbon into the atmosphere slowed down.
5. Recall our earlier work with ocean acidification. How does an atom of carbon move from CO₂ in water into rock? How would an increase in the processes that move carbon into rock impact Earth's temperature?
6. Just for fun: How does an atom of carbon move from HCO₃ in water into carbon in your skin?



Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir		
Longest Residence Time		
Which is more important for driving processes, gravitational or chemical energy?		
How are evaporation and degassing SIMILAR?		
How are evaporation and degassing DIFFERENT?		

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Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

- a. How would this uplift impact the residence time of CO_2 in the atmosphere?

The uplift would increase the residence time of CO_2 in the atmosphere because there is more CO_2 .

- b. Significantly more CO_2 exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO_2 on the weathering rate of rocks found in mountains, monuments, and bricks?

The extra CO_2 causes rocks to weather faster.

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO_2 throughout the entire Earth system.

For example, If the lithosphere is smaller it can't hold as much CO_2 , all of the other reservoirs would have to hold more CO_2 , such as the atmosphere which would contain more.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO_2 throughout the entire Earth system.

If the reservoir ~~residence time~~ has a shorter residence time, other reservoirs will have to compensate so they will have to hold more CO_2 .

Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	Oceans, lakes, ground water	
Processes	evaporation	
Residence Times		

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs:

A large natural or artificial lake used as a source of water supply

2. Evaporation:

The process of becoming a vapor

3. Degassing:

Dissolved gas is removed from water or other liquid solutions.

4. Chemical Energy (when is energy used and when is energy released?)

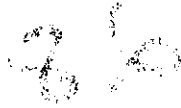
A form of potential energy related to the structural arrangement of atoms or molecules.

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Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	Glaciers Ocean	Limestone
Longest Residence Time	Longest residence times in largest reservoirs.	More or less the same.
Which is more important for driving processes, gravitational or chemical energy?	Gravitational Energy	Chemical Energy
How are evaporation and degassing SIMILAR?	Both processes are the removal of something from a cycle.	
How are evaporation and degassing DIFFERENT?	In evaporation, the sub vapor is the same as the liquid body. In degassing, the gas is pulled from a compound.	



Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.
 - a. How would this uplift impact the residence time of CO₂ in the atmosphere?
 - b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?
2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.
3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

ISP203A – Global Change
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Part 3: Homework

If you complete the group work, you may work on the homework **on your own**. This means your answers should be generally unique from other students' answers. **Submit your homework using ANGEL.**

1. Describe what it means for a reservoir to change size.
2. Describe a situation where the residence time for a reservoir in the carbon cycle is **increased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
3. Describe a situation where the residence time for a reservoir in the carbon cycle is **decreased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
4. How does an atom of carbon move from coal into the atmosphere? Explain what would happen to Earth's temperature if the processes that move carbon into the atmosphere slowed down.
5. Recall our earlier work with ocean acidification. How does an atom of carbon move from CO₂ in water into rock? How would an increase in the processes that move carbon into rock impact Earth's temperature?
6. Just for fun: How does an atom of carbon move from HCO₃ in water into carbon in your skin?

Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
2. A system is in equilibrium when energy in the system is balanced.
3. Matter moves and changes to return a system to equilibrium.
4. Energy is needed to break bonds and is released when bonds form.
5. Temperature is a measure of the movement of molecules. Higher temperature means molecules are moving faster.
6. When molecules move faster, the density of most substances decreases. Water is an anomaly because liquid water is more dense than ice.
7. Buoyancy causes materials to rise or fall due to the relative density of materials.
8. Feedback Loops can accelerate, decelerate, or dampen change.

PART 1: Background Notes

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	Ocean, glaciers, lake, stream	Atmosphere, Biosphere, lith.
Processes	evaporation, condensation, precipitation, infiltration	degassing, burial, weathering
Residence Times	Lower RT: amount of water, inflow & outflow	same

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs:

Places where elements are stored

2. Evaporation:

Breaking down of water molecule? going back into the atmosphere.

3. Degassing:

When CO₂ leaves ocean and goes into atmosphere.

4. Chemical Energy (when is energy used and when is energy released?)

Energy is used to break bonds and energy is released when bonds are broken

Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	Glaciers	Limestone
Longest Residence Time	Oceans	Limestone
Which is more important for driving processes, gravitational or chemical energy?	Both	Both
How are evaporation and degassing SIMILAR?	Both send stuff to the atmosphere	
How are evaporation and degassing DIFFERENT?	Evaporation uses H ₂ O. Degassing uses CO ₂	



Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

- a. How would this uplift impact the residence time of CO₂ in the atmosphere?

This would lower the residence time of CO₂ in the atmosphere because the amount would increase.

- b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

The weathering rate would increase.

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

If the amount of CO₂ increases in the ocean, the amount of CO₂ throughout the entire Earth's system would increase.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

If the amount of CO₂ increases in the oceans, the amount of CO₂ in the Earth's system increases, which decreases residence time.

Part 3: Homework

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1. Describe what it means for a reservoir to change size.
2. Describe a situation where the residence time for a reservoir in the carbon cycle is **increased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
3. Describe a situation where the residence time for a reservoir in the carbon cycle is **decreased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
4. How does an atom of carbon move from coal into the atmosphere? Explain what would happen to Earth's temperature if the processes that move carbon into the atmosphere slowed down.
5. Recall our earlier work with ocean acidification. How does an atom of carbon move from CO₂ in water into rock? How would an increase in the processes that move carbon into rock impact Earth's temperature?
6. Just for fun: How does an atom of carbon move from HCO₃ in water into carbon in your skin?

Objectives

Upon completion of this activity, you will be able to:

- Recognize how carbon moves through the environment.
- Reason about the role of different events in changing CO₂ concentrations in Earth's atmosphere
 - Reason to how this will impact temperature

Causal Principles

1. Gravitational energy, thermal energy and/or chemical energy drive all movement and change of matter on Earth.
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PART 1: Background Notes

Part 1: Class Work

Consider the similarities between the

Table A. Positive Feedback Loop

Characteristic	Water Cycle	Carbon Cycle
Reservoirs	Ocean, glaciers, lakes, streams, clouds, atmosphere, groundwater	Atmosphere (CO_2) (CH_4) Coal Oceans (CaCO_3 , CO_2 , HCO_3^-)... oil Biomass (sugars, organic C) Gas Lithosphere (limestone - CaCO_3)
Processes	Evaporation, condensation, precipitation, discharge, sublimation, infiltration, transpiration	Degassing, Burial, Ocean Acidification, photosynthesis, respiration, weathering, [Humans: cement burning fossil fuels]
Residence Times	Lower residence time; lower amount of water in reservoir, Inflow & outflow.	More or less the same.

Part 2: Group Work

Make sure everyone in your group understands these terms before moving on.

1. Reservoirs: Storage "area" where water and carbon are.
2. Evaporation: liquid to gas change
3. Degassing: Gas going into the atmosphere through a reservoir.
4. Chemical Energy (when is energy used and when is energy released?)
when molecules bond together or break energy is released and that
is chemical energy.



Fill out Table B to the best of your abilities. Multiple correct answers may exist for a single box. Try to include your reasoning along with your answer – What evidence do you have to support your answer?

Table B. Features of the Water and Carbon Cycles

Feature	Water Cycle	Carbon Cycle
Largest Reservoir	Oceans - It is the largest body of water.	Lithosphere - Everything that is pushed below the surface through burial.
Longest Residence Time	Oceans - It's the largest body of water in all 3 stages.	Lithosphere - It stays in the lithosphere unless humans dig edit it out, breathing , or some tough.
Which is more important for driving processes, gravitational or chemical energy?	Both important - chemical energy effects bonds in the Gravitational energy effects the movement from one reservoir to another.	
How are evaporation and degassing SIMILAR?	They both put gas into the atmosphere through a reservoir.	
How are evaporation and degassing DIFFERENT?	Evaporation deals with H_2O and liquids only. Degassing deals with carbon and can come from solids & liquids.	

02

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Questions

1. Imagine we rapidly uplift a large chunk of continental lithosphere to make a huge mountain range. This would expose a large volume of rocks, eventually producing small pieces of rock and chemical products, such as bicarbonate, during weathering. These weathering products make their way into streams and eventually oceans.

- a. How would this uplift impact the residence time of CO₂ in the atmosphere?

Increase, because it is taking carbon out of the lithosphere and putting it into the other reservoirs.

- b. Significantly more CO₂ exists in the atmosphere since the industrial revolution and the widespread use of fossil fuels. What has been the impact of this added CO₂ on the weathering rate of rocks found in mountains, monuments, and bricks?

Increase, because there is a lot more un-natural or man-made weathering occurring making the rate increase.

2. Describe a situation where the size of a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

A giant coal reservoir is dug up and used in factories. This puts more Carbon in the atmosphere and less in the lithosphere.

3. Describe a situation where the residence time for a reservoir in the carbon cycle is changed and how this impacts the residence time of CO₂ throughout the entire Earth system.

If the temperature increased it would increase ocean acidification and increase the residence time because of the oceans size. This would increase the time it takes to make seashells.

Part 3: Homework

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2. Describe a situation where the residence time for a reservoir in the carbon cycle is **increased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
3. Describe a situation where the residence time for a reservoir in the carbon cycle is **decreased** and how this impacts the residence time of CO₂ throughout the entire Earth system.
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